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Travelling risks: How did nanotechnology become a risk in India and South Africa?

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India and South Africa have invested in nanotechnology since the early 2000s and have identified risks to human health and the environment as an important issue for governance. This is exemplary for a wider trend in which 'developing countries' play an increasingly prominent role in the development, production and use of emerging technologies. This validates the claim of the world risk society thesis that countries around the world are now confronted with the risks of emerging technologies. Little is known, however, about the way developing countries deal with the potential risks of emerging technologies. Starting from the observation that the risk colonization of nanotechnology in developing countries cannot be taken for granted, this article draws upon the relational theory of risk in order to investigate how nanotechnology became understood as an object of risk in South Africa and India. The article shows that nanotechnology was constituted as an object of risk in rather different ways in India and South Africa, demonstrating that the spread of risk discourses – and the emergence of a world risk society – cannot be understood without attending to the local context. The article shows that way risk is understood and dealt with changes as risk discourses travel around the world, giving many different faces to the world risk society.

Keywords: travelling risk discourses; nanotechnology; developing countries; India; South Africa; relational theory of risk

Introduction

India and South Africa have been investing in the emerging field of nanotechnology since the early 2000s and can be considered as front-runners amongst developing countries (Court et al. 2004). Whereas the potential risks of nanotechnology have long been absent from government policies and public debate, both governments have meanwhile identified potential risks to human health and the environment as an important issue for governance. This article investigates how nanotechnology became understood as an object of risk by the South African and Indian government, highlighting that the way risk discourses travel cannot be understood without attending to the local context.

Nanotechnology can be defined as the understanding and control of matter at the nano-scale. At this scale, materials gain a number of new properties that may also

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give rise to new risk properties (Oberdörster, Stone, and Donaldson 2007; Hristozov, Gottardo, and Critto 2012). The potential risks to human health and the environment of nanotechnology are considered particularly important because the small size of matter at the nano-scale allows it to find applications in a wide range of products. Since the early 2000s, a broad body of literature has emerged trying to find ways to deal with these risks. These studies range from toxicological research and the development of guidance documents and standards to studies of regulatory procedures, the costs of risk research, and public engagement activities (e.g. Oberdörster, Stone, and Donaldson 2007; Pidgeon and Rogers-Hayden 2007; Choi, Ramachandran, and Kandlikar 2009; Dhawan et al. 2011; Erbis et al. 2016).

Materials at the nano-scale are expected to be widely used in both 'developed' and 'developing' countries. The spread of nanotechnology risks thus validates of the world risk society thesis (Beck 1999), at least to the extent that the risks to human health and the environment that were first considered characteristic for modern industrialized societies have now spread beyond the confines of the world's wealthiest nations that first witnessed their emergence. Countries like India and South Africa are increasingly exposed to the risks of emerging technologies as they do not only import these technologies but increasingly also develop and produce them. Yet while it is beyond doubt that countries around the world are increasingly exposed to risks of emerging technologies, little is known about the way risks are dealt with outside the world's wealthiest nations.

This article aims to open up this field of enquiry by seeking to explain how nanotechnology became constituted as a risk object by the Indian and South African governments. Drawing on the relational theory of risk that approaches risk as a quality ascribed to an object through a social process, I will show that nanotechnology became a risk in rather different ways and that the way nanotechnology was eventually constituted as an object of risk by the governments cannot be understood without attending to the local context. The way risk is understood and dealt with changes as risk discourses travel around the globe, giving many different faces to the world risk society.

Nanotechnology risks

Nanotechnology risks are an interesting case to explore the spread of risk discourses beyond the world's wealthiest nations. The concern that nanotechnology could potentially pose risks to human health and the environment first rose to prominence in North America and Europe in the early 2000s. Several toxicological studies indicated that some nanomaterials may have toxic properties, demonstrating at the very least that there was considerable uncertainty about the safety of nanotechnology (e.g. Oberdörster 2000; Poland et al. 2008). In the following years, concerns about nanotechnology risks quickly rose to prominence following a series of high-profile publications. For instance in 2003, the ETC Group published a review of toxicology studies in which they called for a moratorium on nanotechnology and in the following year the British Royal Society and the Royal Academy of Engineering released an influential report in which they called for more sustained efforts to deal with the potential risks of nanotechnology. Publications like these and others gave rise to efforts to find appropriate methods for testing nanomaterials, labeling nanotechnology products, developing codes of conduct and applying the precautionary principle (e.g. see Renn and Roco 2006; Maynard et al. 2006). Importantly, amongst others

informed by recent experiences with a public backlash against genetically modified organisms in Northern America and Europe, also pro-active attempts were made to engage the public in the governance of nanotechnology risks (e.g. see Pidgeon and Rogers-Hayden 2007; Bowman and Hodge 2007).

While the nanotechnology risk discourse emerged in North America and Europe, so-called 'developing countries' or 'countries from the global South' became particularly active in nanotechnology. Already in 2005 over 30 countries from the global South were active in nanotechnology (Maclurcan 2005) and several developing countries are shared amongst the leading countries worldwide in terms of publications (Zhou and Leydesdorff 2006; Huang, Notten, and Rasters 2011). This is indicative for a wider trend where developing country investments ensure that emerging technologies are no longer the exclusive domain of the West. In 1990, developing countries carried out less than five percent of research and development. In 2002 this number had risen to over 17% and in 2007 developing countries accounted for no less than 24% of research and development worldwide (UNESCO 2010). Especially emerging economies like China, India, Brazil and South Africa are increasingly active at the technological frontier, not only as producers providing labor, but increasingly also as consumers and developers. South Africa was one of the first countries in the world to publish a national nanotechnology strategy and India has even been categorized as a front-runner in nanotechnology worldwide (Court et al. 2004), ranking sixth worldwide in terms of the number of publications, ahead of countries like France and the Netherlands (Beumer and Bhattacharya 2013).

The spread of nanotechnology around the world thus confirms the claim that we live in a world risk society (Beck 1999), at least to the extent countries worldwide are exposed to risks of modern technologies. But this does not mean that risk as a governance concept occupies a similarly central spot on the public agenda of India and South Africa as it does in reflexively modern societies. Nor does it imply that countries like India and South Africa deal with risks in the same way. First of all, there is some anecdotal evidence suggesting that we cannot take for granted that risk discourses are so widely spread in India and South Africa. Asbestos, for instance, which unequivocally is regarded as a risk object in Europe and North America, is almost entirely unregulated by the Government of India. India is the world's biggest asbestos importer and it is a $2 billion industry with double-digit annual growth. As recent as 2011, the Indian supreme court refused to ban asbestos. And in South Africa, information about the health risks of nuclear materials was actively withheld from the workforce in the mines up until the late 1990s (McCulloch 2005; Hecht 2012). Certainly risk discourses have emerged in India and South Africa in the case of other technologies, such as agricultural biotechnology (Damodaran 1999; Cloete, Nel, and Theron 2006; Falkner and Gupta 2009) but the absence of similar discourses in cases of technologies that are firmly understood in terms of risk in Europe and North America demonstrates this cannot be taken for granted.

Secondly, even in cases where risk discourses did emerge, there are theoretical reasons warranting us from assuming that the governments in India and South Africa interpret risk in the same way. For instance, the critical potential of the risk society thesis lies with the observation that modern risks are still dealt with by the institutions associated with first modernity (Beck, Giddens, and Lash 1994). But it is safe to say that countries like India and South Africa did not go through the particular form of modernization that it implied to precede the stage of reflexive modernity and we cannot assume the institutional arrangements associated with the

first modernity are present in similar shapes. Sociologists and historians have likewise pointed out that the concept of risk finds its origins in Europe and that the history of the concept is closely connected to various developments in European history, including the expansion of long-distance trade and the associated emergence of insurance schemes (Luhmann 1993) and the rise of mathematics used by expanding nation-states as a tool for explaining hazard and change (Hacking 1990). The emergence of risk discourses outside of Europe, in places marked by different histories and modernities, thus invariably raises the question how nanotechnology was constituted as an object that poses risks.

Despite the prominence of nanotechnology on the Indian and South African public agenda, there are thus good reasons not to automatically posit that risk occupies a central spot on the public agenda. Nevertheless the potential risks of nanotechnology currently are identified as an important issue for governance by governments in both India and South Africa (Sarma 2011; Musee, Brent, and Ashton 2010; Beumer 2016). This raises the question how risk discourses emerge in India and South Africa – how risk discourses 'travel' from one place to another. Nanotechnology risk in India and South Africa are particularly interesting cases to study the way risk discourses emerge because risk discourses emerged only several years after nanotechnology concerns were articulated in terms of risk in other countries around the world, most notable in Europe and North America, thus allowing a clearer view on the way such discourses travel.

Theoretical background

Over the last 15 years several approaches have been developed that take a constructivist view on the phenomenon of risk. For instance, the relational theory of risk defines 'risk' as the result of the process during which an object is qualified as having a potentially negatively influence on something that is valued, i.e. an object at risk (Boholm and Corvellec 2011; Boholm et al. 2015), constructivist approaches to risk approach 'risk' as a quality ascribed to an object through a social process (Borraz 2008; Hermans 2014), and social representation approaches to risk emphasize how the understanding of particular phenomena in terms of risk is the outcome of sociocultural, historical, and group-specific forces (e.g. Joffe 2003; Bauer 2002). All three approaches highlight the importance of the attribution of meaning and contextual aspects that are involved in understanding and treating phenomena as risks.

In analyzing the way nanotechnology became a risk, I will draw upon the relational view of risk (Boholm and Corvellec 2011) because this is especially designed to allow the analyst to draw attention to the fact that this 'qualification' rests upon views about what constitutes harm and evidence that may diverge between different actors, times, and places. This approach has subsequently been used to explain the cause and persistence of controversies about whether or not something 'constitutes a hazardous object' (Boholm et al. 2015) by pointing out that actors held different views about what can be considered an object at risk, about the evidence required to establish a credible connection between risk objects and objects at risk, and about the consequences that such a connection should be accompanied with. While not denying the fact that some objects can cause harm to human health or the environment, the relational perspective instead shifts the focus away from the question whether or not something can be considered as risk toward the process through which objects are (or are not) constituted as objects of risk by particular actors.

The relational theory can be used to answer 'questions about why and how something is considered a risk' (Boholm and Corvellec 2011) and is therefore well-suited to investigate how nanotechnology was constituted as an object of risk by the governments of India and South Africa.

For the purpose of studying nanotechnology in South Africa and India, it is important to emphasize that the processes by which an objects of risk is constituted are highly context-dependent. Comparative research in risk regulation has highlighted the different ways in which countries calculate, evaluate, compare and manage risk objects (Vogel 1986; Löfstedt and Vogel 2001; Jasanoff 2005). At least a part of the geographical differences in the way objects are constituted as risk objects find their origin in long-established valuations of what can be considered harmful and what can be considered valid evidence. For instance Jasanoff (2005) points out that the British practice of delegating decisions about biotechnology risks to policy officials is closely associated to the long-standing conceptions of the public servant as persons of proven standing while in the United States the constitution of risk objects relied on interested parties such as industry, environmentalists, and academic researchers. And at a different level, when considering the constitution of nanotechnology as an object of risk in India and South Africa, it should be pointed out that the emergence of the modern concept of risk cannot be separated from the eighteenth-century European notions of agency and values that emphasized liberal, rationalistic and pragmatic virtue (Giddens 1990; Luhmann 1993; Bernstein 1996; Reith 2004; Boholm 2015). The contemporary meaning of 'risk' thus has 'considerable historic longevity of a persistent mentality centred upon ideas about human agency, value, gains and losses' (Boholm 2015), whose origins are to be found in Europe.

Certainly the fact that risk discourses are situated in time and place does not prevent them from travelling from one place to another, or from one technology to another. Rothstein and others (Power 2004; Rothstein, Huber, and Gaskell 2006; Huber and Rothstein 2013) have for instance observed how in 'the developed West' more and more practices are framed in terms of risk, 'colonizing' the public agenda, as it were, in order to reflexively manage institutional threats. But the context-dependent historical emergence of risk discourses does provide a valid starting point for understanding what factors facilitate or hamper new objects to be understood in terms of risk and to understand how both risk and the new context change in the process. The wide variety of conditions and factors that facilitated the emergence of risk discourses in Europe and North America should subsequently sensitize the analyst in studying risk discourses in India and South Africa.

The constitution of a risk object is thus understood as a reciprocal process whereby risk changes the way objects are viewed and dealt with in the new context while simultaneously the conditions present in the new context changes the meaning of objects at risk. This insight is closely related to approaches drawing on governmentality theory that approach risk as a discourse that structures ideas and practices related to uncertainty and harm (Dean 1999; Jasanoff 1999). Scholars have pointed out that risk, as a specific discourse about the steering and planning of human action in society, comes along with specific techniques of calculation, decision-making, accountability and foresight (Dean 1999; Reith 2004; Power 2007). As Boholm aptly summarized: 'The concept of risk is therefore accompanied by techniques for making decisions, by modes of praxis and by organizational routines that implicate power relations between expert and layperson, decision maker and stakeholder' (Boholm 2015, 7). The use of the term 'risk discourse', rather than the notion of

'risk' that is used in the relational theory of risk, serves to highlight the way 'risk' structures ideas and practices in ways that have practical consequences. Asking how nanotechnology became a risk hence does not only require investigating the way objects become established as constituting a risk, but also includes investigating the way that this (re)structures ideas and practices related to uncertainty and harm.

Methodology and sources

The emergence of risk discourses concerning nanotechnology in India and South Africa is traced by a combination of semi-structured qualitative interviews and in-depth document analysis. I have conducted fifty-seven in-depth qualitative interviews with key stakeholders who have been involved in Indian and South African nanotechnology since the early days. Interviewees were identified in a variety of documents and websites (including scientific publications, newspaper articles, and conference attendance lists.) and through a snowball method by asking interviewees for names of individuals involved in nanotechnology. Interviews were held at over thirty different institutes during five months of fieldwork (see Table 1 for an overview). These include government departments, universities, research councils, NGOs, metrology organizations, and industries.

Next to this I systematically gathered a wide variety of publically available documents, including policy documents, political speeches, newspaper articles, institutional mandates, websites, leaflets, cartoons, and public lectures. These documents were collected during the fieldwork periods, by systematically searching through the websites of national and international organizations involved in nanotechnology, and by systematically searching a variety of databases and search engines (Web of Knowledge, EBSCOHOST, Google Scholar, and Google). Together, the interviews and documents provide a rich body of sources for analyzing the way nanotechnology became a risk for the governments of India and South Africa.

India

Risk as a non-issue

How did risk as a discourse that organizes ideas and practices around nanotechnology emerge in India? For a long time, risk to human health and the environment were not an issue in Indian nanotechnology. The government first started investing in nanotechnology in 2001 through a scheme called the Nano Science and Technology Initiative and stepped up its investments under the Eleventh Five Year Plan (2007–2012) when a program named Nano Mission was launched that provided funding for centers of excellence, laboratory equipment, and research projects throughout the country. This funding program was initiated at the Department of Science and Technology based on the idea that investments in advanced technologies are a requirement for attaining development. By keeping up with the scientific frontier, India could be propelled onto the world stage, even making it a world leader (Beumer 2015). As the Planning Commission noted when discussing the potential benefits of nanotechnology for ICT, nanotechnology 'represents a "make or break" opportunity, capable of catapulting India into a high growth orbit and on a fast track to becoming a developed nation' (Planning Commission 2008, 252).

Table 1. Institutional affiliations of interviewees.

Country	Institute
India	Bureau of Indian Standards Central Drug Research Institute Department of Information Technology Department of Science and Technology Development Alternatives DSM India Innovation Center Indian Institute of Chemical Technology Indian Institute of Technology Delhi Indian Institute of Toxicological Research Jawaharlal Nehru University National Council for Science and Technology Communication National Institute for Science, Technology And Development Studies National Institute of Pharmaceutical Education and Research National Physics Laboratory Public Health Foundation of India Research and Information System for Developing Countries South Asian University Technology Information, Forecasting and Assessment Council The Energy and Resource Institute University of Hyderabad Vigyan Prasar
South Africa	Council for Scientific and Industrial Research Department of Science and Technology iThemba LABS National Institute of Occupational Health National Metrology Institute of South Africa National Research Foundation Prime Product Ltd. South African Agency for Science and Technology Advancement South African Bureau of Standards Tshwane University of Technology University of Cape Town University of Johannesburg University of Pretoria University of Witwatersrand

In Europe and Northern America, debates about risks to human health and the environment had ensued not long after the first Indian investments in nanotechnology, following publications by organizations such as the Canada-based ETC group and the British Royal Society and Royal Academy for Engineering (ETC Group 2003; RS & RAE 2004). But these European and American debates did not automatically trigger similar discussions in India. Whereas by the mid-2000s several programs had been started in Europe and Northern America for trying to find ways to deal with nanotechnology risks, the Government of India exclusively focused on the developmental benefits of the technology. For a long time the only time that a government official publically spoke about risks, was when Vice-President Hamid Ansari noted in 2008 that 'new and revolutionary technologies always come as a package – with the promise of new opportunities and the threat of new risks' (AZoNano 2008). The government's activities were limited to occasionally funding

risk research projects through the Nano Mission and a largely failed attempt to develop guidelines to assist the regulatory approval of nanotechnology-based drugs. The development of these guidelines was started in 2006 at the National Institute of Pharmaceutical Education and Research. In 2011, it was already observed that 'after five years, there is no word on its progress' (Sachan 2011) and when interviewing a leading toxicologist involved in the program in 2012, these guidelines seemed to have been abandoned entirely. Official government documents did not even mention risks once until 2010, almost a decade after the government started investing.

Non-governmental organizations

Whenever risk did emerge on the public agenda in these early days, this was predominantly due to the efforts of various non-governmental actors. Most prominent amongst these were The Energy and Resource Institute, a civil society organization working on issues of governance, and the Institute for Toxicology Research, a public research institute that is part of the Council for Scientific and Industrial Research (CSIR).

The Energy and Resource Institute (TERI) first started working on nanotechnology in 2007 after receiving funding from the Canadian development organization for a project on capacity building for nanotechnology governance. Risk soon took an important place in their work. They wrote a series of reports and organized several workshops aiming to spread awareness about nanotechnology risks, urging the government to take action to mitigate the potential harm (TERI 2008, 2009a). TERI's emphasis on risks partly emerged in response to a lack of government activities in the area. As Srivastava and Chowdhury, two employees of TERI, put it in 2008: 'the entire orientation of the current institutional and policy framework is towards strengthening technology development and its uptake by the industry. This has meant a significant neglect of the regulatory aspects relating to environmental, health, safety and ethical dimensions' (Srivastava and Chowdhury 2008). But the understanding of possible downsides of nanotechnology in terms of risks was also informed by academic literature from North American and European authors. Enabled by Canadian funding, their work extensively compared the lack of Indian risk governance with the way foreign – mostly European and North American – countries addressed these issues (TERI 2009b, 2010). The fact that the TERI team consisted not only of natural scientists but also social scientists may furthermore help in understanding the way TERI made sense of nanotechnology as both an opportunity and a risk (see Bertoldo et al. 2016).

The Indian Institute for Toxicology Research (IITR) started working on nanotechnology risks two years before, in 2005. Whereas natural scientists have generally been found to represent nanotechnology in terms of opportunities rather than risks (Bertoldo et al. 2016; Besley, Kramer, and Priest 2008), the research group's focus on toxicology naturally directed these researchers to constitute nanotechnology as an object of risk. The researcher who initiated much of these activities had first learned about nanotechnology risks in 2005 while on a sabbatical leave in the United States and upon returning in India he managed to acquire laboratory equipment required for studying materials at the nano-scale. He mentioned: 'I was initially met with scepticism and I had trouble getting the right instruments. Luckily, my director did see the potential importance of my work and allowed me to go ahead with it' (interview 9 December 2010). The equipment was purchased using

funds that are annually earmarked for CSIR institutes, thus largely falling outside the direct control of the Department of Science and Technology. In the years that followed, the IITR developed a highly visible research group in nanotoxicology. The research group occasionally received funding from nanotechnology programs such as the Nano Mission but a substantial part of their funds were also derived from participation in European framework program projects like NanoLINEN and NanoValid. Their work was published in various international journals and the group also made a sustained effort to give visibility to their findings within India by communicating their results in local journals and newsletters.

In the wake of the IITR work, other research institutes also started working on nanotoxicology. The governmental funding schemes that occasionally funded the IITR also provided ad hoc funds to other institutes investigating nanotechnology risks and there is some evidence that also other government bodies started to fund risk research, including the Indian Council for Medical Research and the Ministry of Environment and Forests. By the end of the 2010s, a series of research institutes were conducting risk research, including the Indian Institute for Toxicology Research, the Indian Institute of Chemical Technology, the Amrita Center for Nanosciences, the Central Drug Research Institute, the National Institute of Pharmaceutical Education and Research, and the All India Institute of Medical Sciences (Jayanthi, Beumer, and Bhattacharya 2012).

By the end of the decade, individuals involved with nanotechnology at universities, research councils, standardization organizations and industry spoke about the downsides of nanotechnology in terms of risk. Several of these actors had learned about nanotechnology risks through the work of TERI and the various research institutes mentioned above. But the discourse of nanotechnology risk also traveled from Europe and Northern America in more incidental ways. The majority of interviewees told me that they first heard about nanotechnology risks and the need to deal with them when attending conferences abroad, from foreign collaborators, international newspapers and newsletters, or simply by using Google. The results was that by 2010 pretty much all actors involved in nanotechnology argued that the government should address the potential risks of nanotechnology.

Announcing a regulatory board

When the government announced a regulatory board for nanotechnology in January 2010, however, another event played a catalyzing role. Not the increasingly diverse support for risk governance, but the Indian ban on genetically modified eggplant triggered the government into action. Agricultural biotechnology had long been a controversial topic in India, but biotechnology had thus far been dealt with in a largely technocratic manner. This changed by the end of 2009 when the new environmental minister organized a set of public hearings and on the basis of these put a moratorium on genetically modified eggplant, or Bt brinjal (Shah 2011). While several concerns lie at the basis of this controversy, including private ownership over agricultural input and the ensuing dependency of small-holder farmers on multinational companies, the decisions were nevertheless largely framed in terms of risks to human health and the environment. For those government officials in charge of nanotechnology affairs, this unprecedented development in the Indian context was a clear signal that public concerns about risks could indeed affect government conduct. Even if evidence on public concerns about nanotechnology risks was entirely

absent (Beumer 2014), the ban on Bt brinjal nevertheless generated a situation similar to Europe and North America, where the emergence of nanotechnology risk discourses was strongly shaped by concerns over public opposition to genetically modified organisms, as was described in the section on 'nanotechnology risk'. As one prominent nanotechnology scientist said: 'the reason we had problems with Bt brinjal is because we don't have a strong regulatory body' (C.N.R. Rao quoted in Sarma 2011). The moratorium on Bt brinjal was announced in the first week of January 2010 and two weeks later the head of the Nano Mission announced a regulatory board responsible for taking care of nanotechnology risks.

The regulatory board was initiated by the Nano Mission at the Department of Science and Technology. There were several other governmental divisions that were perhaps more obvious candidates for taking up the discourse of risk in addressing nanotechnology concerns. For instance the Ministry of Health and Family Welfare, the Ministry of Environment and Forests, and the Ministry of Labor each have mandates that could accommodate the task of addressing nanotechnology risks (TERI 2009a; Sarma 2011). The Department of Science and Technology on the other hand is mandated to promote science and technology and several commentators critically argued that their promotional orientation may conflict with their activities in addressing risks (Sarma 2011; Jayanthi, Beumer, and Bhattacharya 2012). Yet it was the Department of Science and Technology that took the lead in its capacity of the nodal agency for nanotechnology.

The step to institutionalize risk discourses by establishing a regulatory board, rather than for instance urging existing regulatory bodies to include nanotechnology risks, to some extent follows from the nature of the technology. Centralizing the governance of risks can be said to be beneficial in the case of a technology whose applications span different sectors; the fact that nanoparticles can be used in a variety of sectors could be an argument not to organize the governance of risks along sectorial lines. But the establishment of a separate regulatory board should also be understood with reference to other domains where risk discourses have emerged in India. For instance in the case of biotechnology, which we already saw had a direct influence on the emergence of a risk discourse in nanotechnology, the government also decided to create a set of new institutes responsible for risks to human health and the environment. This stands in a long tradition of 'mission-oriented research' in India (Raina 2012). Building upon notions of big science, this refers to the idea that technological advances can best be achieved by creation 'mission-oriented' institutes that are exclusively dedicated to a technological field, thereby enabling people with different backgrounds and interests to work toward a shared goal (Kalam 2012). These institutes were then accompanied by another institute responsible for governing possible risks – like the Nano Mission nowadays, and like technologies like biotechnology, space research, and nuclear energy before it.

The announcement of the regulatory board was the first time the government adopted the discourse of risk in the case of nanotechnology. After the announcement of the regulatory board in 2010, however, little visible activities took place and calls for government action persisted. For instance, in 2011, two major Indian companies called for government action by publically announcing that they abstained from developing nanotechnology products because of a lack of regulatory standards (Bakshi 2011). The little government work that has been done in the last few years was moreover obscured by the rather non-transparent manner in which the regulatory board proceeded. For instance, the Nano Mission director informed me in an

interview in 2012 that the committee had produced guidelines for dealing with nanotechnology in research laboratories, following the work of researchers from the IITR who had earlier published a guidance document for dealing with nanomaterials in the workplace (Dhawan et al. 2011). The guidelines, however, were not yet available because they were still under discussion within the Department of Science and Technology (and to the best of the author's knowledge they still have not been published).

Government activities

In recent years the regulatory board (now referred to as an expert committee) has nevertheless initiated several activities. But while one can say India had hereby adopted the risk discourses on nanotechnology that had earlier emerged in Northern America and Europe, this by no means implies that India governs risks in the same way as European and North American countries. Through qualitative interviews with several members of the expert committee as well as close observers, it can be discerned that their work mainly consists of developing the guidelines mentioned above, monitoring how risks are dealt with internationally, and at times funding risk research.

The Government of India positions its own activities in addressing risk as a small part of a global field of scientific inquiry. Government officials for instance pointed out that 'as a developing country', India cannot be expected to take the lead and rather should follow what the rest of the world is doing (interview 12 November 2012). This interpretation of risk as an international field thus served to limit the activities required for addressing risk concerns to following the activities of 'developed' countries. This was for instance translated into the task of monitoring international risk governance efforts. Also the guidelines mentioned above follow this logic as they are were designed by combining elements of several guidelines developed abroad. Apart from the question whether such a wait and see approach will be beneficial for India as it may imply that crucial decisions about the design of risk governance strategies are left to countries with rather different socioeconomic conditions and interests, it is also worth pointing out that this way of framing risk stands in sharp contrast to the way benefits are framed in India. When it comes to risk, India positions itself as a developing country with limited resources, while it positions itself as a potential world leader when it comes to the benefits.

The government's work is further characterized by a regulatory approach in which regulatory action is only justified when supported by certain knowledge. This fits within a broader trend in the Indian governance of nanotechnology whereby science is given a central role in decision-making (and claims and concerns by other actors are regularly dismissed) (Beumer 2016). In interviews with government officials, it was repeatedly made explicit that the government will only take action when international experts arrive at a consensus about both the existence of risks and the best mechanisms for dealing with those risks. This approach speaks of a notion of risk that is sharply distinct from what can be termed 'uncertain risks' (van Asselt and Vos 2008). While the uncertainties concerning the effects of nanotechnology on human health and the environment did not prevent several measures to be taken in other countries, often under the umbrella of the precautionary principle, in the Indian context these uncertain risks provide insufficient justification for any action other than risk research. A prominent Indian nanotechnology scientist summed this up

quite effectively when noting that there are 'many things we don't know yet. But once we know we must take care' (interview December 15, 2010).

The risk discourse from the Indian Government further structured the way concerns were addressed by portraying risks and benefits as a trade-off. Besides the insistence that no regulatory action can be taken in the presence of scientific uncertainty, another important concern was the fear that regulations may hinder technological progress. The director of the Nano Mission for instance emphasized that whereas the government initiated the expert-committee because they want to avoid being careless, they equally want to avoid over-regulating nanotechnology because this may stifle technological development. While a valid point in and of itself, this is nevertheless a curious thing to say in a context where no concrete regulations have been introduced and companies refrain from putting nanotechnology products on the markets because of the lack of regulatory standards.

This is not unique to the Indian Government. Also scholars drawing attention to the potential developmental benefits of nanotechnology have argued that dealing with risks should not currently be the priority for developing countries. Overly addressing risk concerns could shy away developing countries from investing in this promising technology, so the argument went, hence pre-empting the development of beneficial technologies (Court et al. 2004). In a similar vein, the government in India pushed for the benefits first, putting the potential risks between brackets, as something that can be dealt with later.

Risk discourses did eventually successfully travel to India and were adopted by the national government. Nanotechnology was constituted as an object of risk through the efforts of civil society organizations and toxicology researchers, through more mundane channels like conference visits and the use of Google, and in response to public discussions about biotechnology in India. In line with the tradition of mission-oriented research, the responsibility to deal with risks was laid down with a separate institute, whose activities were limited by its position as a developing country with limited resources, which could only take action in case of sufficient certainty and after ensuring the benefits were not threatened.

South Africa

Risk as a non-issue

How did risk as a discourse that organizes ideas and practices around nanotechnology emerge in South Africa? The origins of South Africa's engagement with nanotechnology lie in 2002, when the Department of Science and Technology requested a group of scientists to discuss the possibilities to participate in the European Framework Programme. The thematic priority on nanotechnology and nanosciences was open for participation of non-European countries and South African scientists may be able to get some funding. The group of scientists formed an organization, the South African Nanotechnology initiative (SANi), which helped articulating the role of nanotechnology in South Africa. In 2006, the parliament adopted a national nanotechnology strategy which was jointly written by SANi and the Department of Science and Technology, and the government provided an initial fund of 450.000 Rand (about 60.000 Euros) over three years. The government has since increased the financial means available and funded research projects, created a nanotechnology equipment funding scheme, and established several centers of excellence, amongst others.

As in India, the government and the scientific community were long silent about risk. The 2006 nanotechnology strategy does not mention the term risk and makes only a general reference to the need for addressing concerns about health and the environment when noting that the government should analyze and introduce 'legislative instruments to ensure that Nanotechnology is applied according to international best practice in industrial and environmental safety standards' (DST 2006, 5). Instead, the focus was strongly on achieving benefits in what were called the 'societal cluster' and the 'industrial cluster'. The social cluster refers to the development of nanotechnology applications that could help solving problems related to the quality of life, in particular in the areas of water, energy, and health. The industrial cluster refers to applications that could strengthen South Africa's competitiveness by developing applications for the country's main industries in the fields of mining and minerals, chemical and bioprocessing, and materials and manufacturing. Whereas India aimed to achieve development objectives by being at the global scientific forefront, South Africa focused on applications in areas that had prior been identified as national priorities (Beumer 2015). Yet despite the diverging ways in which nanotechnology was expected to contribute to development objectives, in both countries risks were initially no part of their strategies.

Rapid adoption

The way nanotechnology was constituted as an object of risk diverged from India in that two of the main actors in India – civil society and toxicologist – were less vocal in South Africa. The absence of civil society organizations in South African nanotechnology discussions stands out as remarkable, as civil society has played a prominent role in the emergence of nanotechnology risk discourses around the world (e.g. ETC Group 2003; Krabbenborg 2013). South African toxicology researchers started working on nanotechnology in the second half of the previous decade and by 2008 at least six research institutes were working on the topic, including the National institute of Occupational Health, the Council for Scientific and Industrial Research, and the University of Pretoria, Stellenbosch University, the University of Witwatersrand and Rhodes University (Musee 2009) but the scope and visibility of their work initially remained limited (Beumer 2016). Instead, risk discourses travelled to South Africa mainly through the more 'mundane' channels that we also saw in India. Interviewees mentioned they had first heard about the potential risks of nanotechnology through scientific journals, the Meridian Institute newsletter on nanotechnology and development, contacts with colleagues at international conferences, and other informal contacts with scientists from Europe and North America. By the turn of the decade, like in India, most actors involved in nanotechnology in South Africa were well-aware of nanotechnology risk.

As compared to India, where civil society organizations and prominent toxicologists publically spoke out on the need to govern nanotechnology risk, in South Africa nanotechnology was first constituted as an object of risk in a more dispersed manner through the Internet, email lists, and foreign collaborations, leading one to expect that risk discourses was adopted both slower and less widespread in South Africa. But this is not what happened: in South Africa risks were widely circulated and were quickly embraced by actors across the board.

This can partly be attributed to the role of science and technology in post-Apartheid South Africa. When the African National Congress (ANC) finally rose to power in 1994, the priorities were firmly put on issues of employment, housing, agricultural land and other issues that could serve to undo the inequalities of Apartheid. Unlike India, where nanotechnology was considered a force of change that could turn the country into a developed country, in South Africa science and technology were not on top of the public agenda (Marais and Pienaar 2010). Where in 1991 South Africa spent 1.03% of its gross domestic product on research and development, this had dropped to a mere 0.68% in 1997 (Cherry 2006). As one interviewee made clear:

> science and technology is bidding against Higher Education which is creating schools in rural areas. Then it is competing with the Department of Health, which is putting clinics in those places. Then we compete with the Department of Houses where you need to make homes for the poor and the Department of Water Affairs where you want to get good quality of water running through theses homes. (interview 4 October 2011)

This helps to explain why the nanotechnology strategy focuses on developing applications that serve well-established national priorities in water, energy, health and mining. And it also helps to explain the emergence of the earlier mentioned South African Nanotechnology initiative (SANi) as the organization where South African actors involved in nanotechnology organized themselves. In a context where science and technology were struggling to retain the little funds it had, scientists across the board had to speak in one voice. Consequently, when nanotechnology was first constituted as an object of risk in emails, foreign newsletters, and conferences, this was quickly circulated within the SANi network and was widely quickly embraced as a legitimate concern, including by the South African Government.

Government activities

While the 2006 nanotechnology strategy did not mention the term risk once, in 2007 the Department of Science and Technology announced the creation of a research platform to investigate the risks of nanotechnology to health, safety, and the environment (HSE). The main task of the HSE platform was to identify research priorities and they set out by creating a review of international scientific publications on nanotoxicology and making 'an inventory of the nanoproducts and nanomaterials in use, production or imported in South Africa' (Musee 2009). When the government officially launched the HSE platform in at a 2009 workshop, the mandate of the platform had expanded from coordinating risk research to ensuring safety itself. The civil servant in charge noted at the workshop that the research platform has 'its core focus on uncovering *and mitigating* health, safety and risk issues associated with research development and application of nanotechnology' (Molapisi 2009 [italics added]).

By the end of the same year, however, their plans changed when South Africa received an invitation to the OECD working party on manufactured nanomaterials. South Africa first attended a meeting in late 2009 and its approach toward nanotechnology risk has been strongly informed by its participation in the working party ever since. In particular, this meant that the South African priorities in risk research were aligned to the work of the OECD working party. In 2007, the working party had decided to limit their risk assessments to a restricted number of representative nanomaterials that were close to commercialization (OECD 2011). The OECD selected

13 representative nanomaterials for risk assessments and South Africa took the pro-active step to become lead sponsor for one of those materials – gold – despite there being 35 member in the committee, and despite South Africa not being an OECD country (South Africa received an observer status in the working party). Most of the government's resources were soon directed toward the risk assessment of gold nanoparticles and four prominent South African research institutes subsequently focused on the hazard identification, risk characterization, and studying the physicochemical properties of gold nanoparticles (Gulumian 2012).

Strategic positioning

The rationale for redirecting domestic efforts along the lines of the OECD was that South Africa wanted 'to contribute to global efforts to address this challenge of not knowing the risks of nanomaterials' (interview September 16, 2011). Similar phrases were repeatedly put forward by scientists and government officials. This stands in sharp contrast to the Apartheid era, when South African was subject to international sanctions that sought to isolate the country. This not only prevented scientists from 'contributing to global efforts', the South African Government actively used to isolation as an element in nation-building. For instance Edwards and Hecht (2010) show how the 'South African' nature of nuclear systems became the subject of political struggles. Whereas the Apartheid state sough to demonstrate self-sufficiency by building nuclear systems despite the international isolation, anti-Apartheid activities in turn challenged such claims by demonstrating the dependence of South Africa's nuclear capabilities on international knowledge networks. In the case of nanotechnology risks, however, contributions to global efforts could be stated publically in a context where the government actively tried to put the Apartheid legacy behind them.

The strong emphasis on international collaboration further can be understood by looking at the way actors in South Africa perceive the benefits of nanotechnology. Whereas India sees itself as a future world leader that should chart its own course, South Africa generally positions itself as a small and vulnerable player and partly invested in nanotechnology because it did not want to fall behind the rest of the world. The national nanotechnology strategy states that 'ignoring nanotechnology' may result in a decline in competitiveness of manufacturing industry and a decrease in international investments in South Africa because of 'non-compliance with advances in world technology' (DST 2006, 15). These concerns are particularly pertinent in view of recent economic experiences in South Africa, where a series of neoliberal reforms that were meant to strengthen the value of the Rand after the end of the Apartheid, resulted in a disadvantageous exposure to international competition and a resultant decline in competitiveness (Carmody 2002). In such a liberalized market, the aim of the nanotechnology strategy to develop nanotechnologies in the industrial sector is essentially dependent on the possibility to export these products to international markets, thus making adherence to best practices in risk governance of paramount importance.

The choice to take the lead in assessing the risks of nanotechnology gold directly followed from the government's strategy for realizing nanotechnology benefits. A major driver for South Africa to funnel funds toward the 'industrial cluster' was the fear that foreign nanotechnology developments could negatively impact South African exports. Several commentators had pointed out that the special properties of nanotechnology could theoretically be used to develop cheap materials mimicking

the properties of rare and expensive materials, such as gold, thereby threatening developing country exports of rare minerals (Schummer 2007; Wetter 2010). As the world's leading exporter of gold and platinum, South Africa's investments in the 'industrial cluster' aimed to use nanotechnology in order to find new uses for its most important minerals, which was for instance put into practice by establishing one of the country's two nanotechnology innovation centerss at MINTEK, a gold research institute. On the one hand this knowledge about gold gave South Africa a strategic vantage point to investigate the risks of gold nanoparticles. One government official told me South Africa decided to focus their risk research on gold 'because we are rich in gold and have been using gold nanomaterials for quite a long time' (interview September 28, 2011). On the other hand, investigating the risks of golden nanoparticles could serve the commercial pursuit of novel applications for gold. For South African companies that want to put their products on the European market, so a prominent toxicologist told me, it is important to keep a close eye on international developments related to risk.

As this example also shows, the South African Government's approach to nanotechnology risk was further underpinned by a relation between risk and benefits where the governance of risk was seen as a precondition for reaping the benefits. Another prominent nanotoxicologist, who repeatedly represented the South African Government at the OECD, for instance noted that the health, safety and environment research platform was established '*to ensure nanotechnology-driven benefits* (…) are exploited safely, responsibly, and sustainably' (Gulumian 2012 [italics added]). And at the launch of the HSE platform, the government official responsible for nanotechnology clearly stated that 'the expected outcomes as stated in the research plan [the nanotechnology strategy], and the strategic objectives, cannot be adequately realized if the health, safety and risk issues associated with the development and application of nanotechnology are known and given the necessary attention' (Molapisi 2009). This strongly contrasts to India, where risks and benefits were seen as a trade-off and where any attention to risks was perceived as potentially threatening the benefits. In South Africa, on the contrary, governance of risk was seen as a precondition for reaping the benefits.

Nanotechnology was eventually also constituted as an object of risk by the South African Government. After arriving in South Africa through a variety of channels ranging from email lists to conference visits, nanotechnology was quickly constituted as a risk object when risk discourses quickly circulated in the networks of the SANi and the government. In contrast to the international isolation under the Apartheid Government, the South African Government closely coordinated their work with international activities through the OECD. By working on gold nanoparticles, South Africa aimed to contribute to international research efforts while at the same time strengthening their strategic position as was outlined in their nanotechnology strategy. Considering the governance of risk as a precondition for reaping the benefits in an international market place, they focused their efforts on those nanotechnologies that South Africa hopes to reap most benefits from.

Conclusion

The starting point for this article was that the presence of risk discourses – or the risk colonization of nanotechnology in developing countries – is something that needs to be explained. While the growing investments in emerging science and

technology by countries in the global South increases the likelihood that they are exposed to the potential harms of those sciences and technologies, this does not mean that these harms are also understood and dealt with in terms of risk. Nanotechnology risk in India and South Africa offered a good case study in this respect as risk discourses were initially absent in these countries and emerged only after they had been well-established in other countries. I have proposed that the way risk discourses 'travel' to nanotechnology in India and South Africa can be investigated by taking a relational perspective on risk. I traced how nanotechnology was constituted as a risk object using a comparative approach, drawing upon semi-structured qualitative interviews with key stakeholders in India and South Africa as well as a wide range of written sources.

The comparative approach adopted in this article revealed that the way nanotechnology is constituted as a risk object varies from place to place. Nanotechnology was constituted as a risk object by the Indian Government after the Canadian development organization funded a civil society organization, who heavily drew upon international literature on nanotechnology risks; after toxicologists learned about nanotechnology risks in the United States and partly funded their research by participating in European funding schemes; and after a variety of actors learned about nanotechnology risks through emails, newspapers, international conferences and foreign collaborators. Foreign discussions about nanotechnology risks thus exerted a significant influence on the emergence of risk discourses within the Indian Government – risk discourses 'travelled' from abroad, one could say – but risk discourses also travelled from other domains within India: concerns about nanotechnology also partly became understood in terms of risks because of the influence exerted by risk discourses in the case of agricultural biotechnology. In South Africa toxicologists also started working on nanotechnology risks but nanotechnology was constituted as a risk object mostly after actors learned about it through a variety of everyday acts of communications, such as emails, newsletters, and contacts with foreign collaborators. Also in South Africa foreign risk discourses played an important role in the constitution of nanotechnology as a risk object by the government. But whereas the Indian and South African Government adopted a risk discourse that originated in Europe and North America, they were not unilaterally forced to do so through international agreements, as is for instance regularly argued in the case of intellectual property rights and trade regulations. This article found that in the case of nanotechnology risk discourses, international email lists and conferences were at least as influential.

The comparative approach further enabled us to see that once nanotechnology was constituted as a risk object, nanotechnology was identified, understood, and made relevant as an object of risk in rather different ways. In India for instance risk is predominantly understood as a potential threat to the benefits of nanotechnology. The government rather reluctantly took up the governance of risk after being faced with increasing pressure by civil society, scientists, and industry, as well as changes in the domain of agricultural biotechnology. They eventually set up a regulatory board whose activities largely consists of monitoring foreign developments and taking action when there is sufficiently certain knowledge about both the existence of risks and the best ways to deal with them. In South Africa, on the contrary, the governance of risk is considered a precondition for reaping the benefits and was quickly embraced by actors across the board. The government set up a research platform to

investigate how best to deal with risks, which was quickly superseded by South Africa's participation in the OECD working party on manufactured nanomaterials. South Africa subsequently geared its activities to both global efforts and their attempts to reap the benefits of nanotechnology by pro-actively taking the lead in investigating the risks of golden nanoparticles. In other words, the way 'risk is identified, understood, and made relevant' (Boholm 2015) does not remain stable as new technologies are constituted as risk objects in new places.

Certainly the emergence of risk discourses is related to some of the broad conditions under which risk discourses emerged in Europe and Northern America, such as the development of markets and the responsibilization of the state to provide safety to their citizens. But the differences in both the way risk discourses emerged and the form they eventually took in India and South Africa can best be understood by looking at the local context in which risk discourses emerged. The methodology section highlighted that the way risk discourses emerge should be seen as a reciprocal process whereby on the one hand the constitution of a risk object changes the way objects are viewed and on the other hand this process is simultaneously informed by the conditions already present in the new context. For instance, in India, the government's decision to create a separate regulatory board should be understood in light of the long tradition to create technology-specific institutions as part of their mission-oriented research endeavors and the view of risk as a potential threat to the benefits directly follows from the almost unquestioned position of science and technology as bringers of development. In South Africa, risk discourses circulated so quickly because various stakeholders had been strongly organized in the South African Nanotechnology initiative in order to be able to speak in one voice to a government that was otherwise skeptical of investments in new science and technology. The decision to focus their efforts with respect to risk on golden nanoparticles should be understood in the same light, where the benefits of nanotechnology were primarily said to reside in already existing national priorities that were deemed under threat.

Just like the differences in which various European and North American countries calculate, evaluate, compare and manage risk objects should be understood as the products of a variety of local conditions (e.g. Vogel 1986; Löfstedt and Vogel 2001; Jasanoff 2005), so the different ways in which nanotechnology was constituted as an object of risk by the governments of India and South Africa are grounded in local histories. One element of the local context found in this article that was not yet so much highlighted in the literature on the conditions under which risk discourses emerge is the way countries position themselves in relation to foreign countries. The pro-active step of South Africa to become the lead sponsor for golden nanoparticles within the OECD working party for instance cannot be understood without looking at the way South Africa positions itself as a small and vulnerable player on the global stage that is eager to undo the international isolation endured under Apartheid. And we saw that India justified its strategy to follow foreign developments by positioning itself as a developing country, which subsequently could not be expected to take the lead, despite the fact that they do claim to take the lead when it comes to the benefits. As the latter example shows, the distinction between the 'country' and 'the foreign' is not of analytical value in studying how risk objects are constituted in particular geographies, they are also drawn upon by countries themselves in order to inform the way risk objects are constituted.

Risk discourses have travelled beyond the confines of the wealthy countries that were first characterized as risk societies. As countries worldwide increasingly engage with modern sciences and technologies – as both consumers, producers and developers – it becomes increasingly important to gain insight into their understanding of risk. In doing so, it is paramount not merely to juxtapose best-practices developed in Europe and North America to the state-of-the-art in so-called developing countries in order to assess whether or not countries in the global South live up to 'global standards'. Rather, as countries from the global South will take in a more prominent position in international negotiations over science and technology-related trade regulations, risk governance, and standards, the notion of what 'global standards' are is likely to shift in ways that are informed by risk discourses in the global South. Gaining insight into local risk discourses, as can be made visible by investigating how risk discourses emerge, offers a view onto the different faces of the world risk society.

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